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	Prepared by(s) Bernard F. Phlips Gilles Bogaert	Supersedes None
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Document Title **Specification for the Calorimeter PIN Photodiode Assembly (Flight Units)**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Specification for the Calorimeter PIN Photodiode Assembly

(Flight Units)

DOCUMENT APPROVAL

Prepared by:

Bernard Phlips Naval Research Lab	Date
Gilles Bogaert IN2P3 Ecole Polytechnique	Date

Approved by:

W. Neil Johnson CAL Subsystem Manager	Date
Didier Bédérède LAT Project Manager, France	Date
Nick Virmani CAL R & QA	Date

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1 PURPOSE

This document specifies the mechanical, optical and electrical characteristics of the PIN photodiode assembly for the Calorimeter (CAL) subsystem of the GLAST Large Area Telescope (LAT). This assembly consists of a ceramic carrier containing two Silicon PIN photodiodes. The optical window of the assembly is coated with a clear epoxy resin.

2 SCOPE

These specifications apply to the PIN photodiode assemblies that will be incorporated into the flight quality modules of the Calorimeter subsystem of the GLAST LAT. Approximately 4400 diodes are required for the flight instrument and spares.

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This release of the specification applies to the Engineering Model prototype PIN photodiode assemblies only. These diodes shall be manufactured, to the extent possible, with identical materials and processes as the flight instrument diodes but with documentation and quality assurance procedures more commensurate with commercial fabrication procedures. This will allow the vendor to establish process parameters and manufacturing methods for the flight hardware. The details of the manufacturing and quality controls for the flight procurement shall be negotiated with the vendor and this specification shall be modified to reflect new applicable requirements from MIL-PRF-38534 and MIL-STD-883 that are acceptable to the GLAST project at NASA/GSFC. NASA/GSFC project and the LAT management shall review the specification for flight parts prior to procurement.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
GLAST	Gamma-ray Large Area Space Telescope
EM	Engineering Model
FM	Flight Model
GSFC	Goddard Space Flight Center, NASA
LAT	Large Area Telescope
NASA	National Aeronautics and Space Administration
TBR	To Be Resolved

3.2 Definitions

γ	Gamma Ray
μsec, μs	microsecond, 10^{-6} second
nm	nanometer
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million Electron Volts, 10^6 eV
ph	photons

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT Calorimeter and its requirements include the following:

LAT-SP-00010	"GLAST LAT Performance Specification", August 2000
LAT-SS-00018	"LAT CAL Subsystem Specification", January 2001
LAT-DS-00072	Specification for the Calorimeter PIN Photodiode Assembly (Engineering Model Prototypes)

GLAST00110	"Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", NASA Goddard Space Flight Center, Current Draft Sept 20, 2000
NPD 8010.2B	"NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"
Hamamatsu Photonics K03-B70065	Specification for the Silicon PIN photodiode, S3590 SPL 2CH, dated 6 August 1998.
MIL-PRF-19500	Performance Specification for Semiconductor Devices
MIL-STD-750	Test Methods for Semiconductor Devices
EIA-625	Requirements for Handling Electrostatic Discharge Sensitive Devices (ESDs)

5 INTRODUCTION

The GLAST mission is a NASA-launched gamma-ray mission to be launched in 2005. The expected mission lifetime is greater than 5 years. The Large Area Telescope (LAT) instrument is the primary experiment on GLAST and consists of an Anticoincidence Device, a silicon-strip detector tracker, a CsI calorimeter (CAL), and a Trigger and Dataflow system. The principal purpose of the LAT is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The LAT calorimeter is a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4 × 4 array of identical modules. Each module is a hodoscopic array of 96 CsI scintillation crystals and associated readout electronics. Each crystal is approximately 27 × 20 × 336 mm in size with a PIN photodiodes attached on each end.

Two photodiodes, one large and one small, are required at each end of the crystal to support the electronic measurements over the required dynamic range of the energy depositions. These two diodes are mounted in a single carrier with a kapton cable interconnect. The diode assembly shall coupled to the CsI crystal using an optical epoxy or a silicon elastomeric casting (similar to Mapsil 213).

This specification identifies the mechanical, optical and electrical characteristics of this PIN photodiode assembly consisting of a ceramic carrier, diode pair, and epoxy optical window.

6 REQUIREMENTS

6.1 Mechanical Configuration

The contractor shall provide two Silicon PIN photodiodes mounted in ceramic carrier.

6.1.1 Case Outline

6.1.1.1 External dimensions

The ceramic carrier shall be 22.3 (±0.2) mm × 15.0 (±0.2) mm × 1.8 (±0.2) mm. (see Figure 1)

6.1.2 Part or Identifying Number (PIN)

A unique part number shall be applied to the back ceramic carrier. Traceability shall be maintained for individual parts that are part of the assembly.

Hand written serial number in ink shall be acceptable for EM parts.

6.2 PhotoDiode

6.2.1 Description

The ceramic carrier shall contain two silicon photodiodes manufactured with Silicon material and controlled processes appropriate for space flight quality parts. We reference the previous GLAST PIN photodiode development at Hamamatsu Photonics, part number S3590 SPL 2CH that was

Table 1. Electrical and Optical Properties of PIN Diode A (small diode) at 20 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area Size	–	–	–	10.5 × 2.4		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S_1	λ = λp	–	0.66	–	A/W
	S_2	λ = 540 nm	0.33	0.37	0.41	A/W
Dark Current	I_D	V_R = 70V	–	1.0	3.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	–	10	15	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	45	–	MHz
Maximum Reverse Voltage	V_{Rmax}		100			V
Depletion Voltage	V_D				70	V

developed for the Naval Research Laboratory in 1998. The Hamamatsu specification number for the S3590 SPL 2CH part is K03-B70065, dated 6 August 1998. This material was ~ 300 μm thick and had ~ 200 μm depletion depth. For the PIN photodiodes defined here, we specify a ~300 μm depletion depth design. The characteristics specified in Tables 2 and 3 are based on the Hamamatsu S3590-08 characteristics.

6.2.2 Performance Specification

6.2.2.1 Diode A

The smaller of the two PIN photodiodes in the carrier shall be designated Diode A and shall have an active area of 10.5 × 2.4 mm. Table 1 specifies the electrical and optical characteristics of Diode A at 20 °C.

Table 2. Electrical and Optical Properties of PIN Diode B (large PIN) at 20 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area Size	–	–	–	10.5 × 14.5		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S_1	λ = λp	–	0.66	–	A/W
	S_2	λ = 540 nm	0.33	0.37	0.41	A/W
Dark Current	I_D	V_R = 70V	–	3.0	10.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	–	65	100	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	35	–	MHz
Maximum Reverse Voltage	V_{Rmax}		100			V
Depletion Voltage	V_D				70	V

6.2.2.2 Diode B

The larger of the two PIN photodiodes in the carrier shall be designated Diode B and shall have an active area of 10.5 × 14.5 mm. Table 2 specifies the electrical and optical characteristics of Diode B at 20 °C.

6.2.3 Photodiode Accommodation

6.2.3.1 Electrical Connections

Bonding and connections to the silicon (TBR).

6.2.3.2 Silicon Photodiode Mounting and Isolation

The two photodiodes shall be mounted in such a manner to preserve electrical isolation. The electrical and optical characteristics of the two photodiodes are addressed in Table 1 and Table 2.

6.2.3.3 Optical Window Material

The photodiodes shall be coated with a clear epoxy resin to protect their sensitive surfaces and to maintain effective and reliable coupling to the scintillation crystals. An epoxy similar to that used in the Hamamatsu Silicon PIN Photodiode S3590 SPL 2CH delivered to NRL shall be used. It is understood that this epoxy has been qualified for space flight in ESA's INTEGRAL program for

Table 3. Absolute Minimum and Maximum Conditions

Parameter	Symbol	Value	Unit	Remark
Reverse Voltage	VR_{Max}	<100	V	
Operating Temperature	T_{opr}	– 20 thru +35	°C	Non-condensing
Storage Temperature	T_{stg}	– 20 thru +50 – 30 thru +50	°C °C	EM Parts, Non-condensing FM Parts, Non-condensing
Temperature Rate of Change		TBR	°C/hr	
Max Atmospheric Pressure		1.1	atmos	
Min Atmospheric Pressure		$< 10^{-6}$	Torr	Must operate in space vacuum

the PICsIT experiment. Any deviation from this epoxy shall be negotiated with the GLAST LAT Calorimeter Team.

6.2.3.4 Optical Surface Flatness

The clear epoxy resin shall fill the ceramic carrier wells for the photodiodes, cover the recessed ceramic isolation wall between the cells, and shall be polished to a flat optical mounting surface. The optical mounting surface shall be flat to within ±2.0 μm.

6.2.3.5 Alignment of Optical Surface to Ceramic Surface

The optical epoxy surface shall be aligned with the ceramic surface to within ±5.0 μm.

6.2.3.6 Absolute Maximum Ratings

Table 3 identifies the absolute minimum and maximum ratings for the photodiode assembly during laboratory testing and ultimate space flight. Note: for the Engineering model parts, the storage temperature range has been reduced.

6.2.4 Radiation Requirements

6.2.5 Technology Flow

6.2.6 Reliability

6.2.7 Certification of Manufacturer

6.2.8 Qualification Requirement

6.2.9 Screening Requirement

6.2.10 Derating Requirement

6.2.11 Program Parts Control Board

6.2.12 Precap Inspections

6.2.13 Destructive Physical Analysis

6.2.14 Subcontractor Controls

6.2.15 Facilities and Standards

6.2.16 Manufacturing Controls

6.2.17 Nonconforming Material Control

6.3 Ceramic Carrier

6.3.1 Specification

The ceramic carrier shall be 22.3 (±0.2) mm × 15.0 (±0.2) mm × 1.8 (±0.2) mm. (see Figure 1)

6.3.1.1 Photodiode accommodation

The two silicon photodiodes shall be mounted in the ceramic carrier with isolated wells for each diode as indicated in Figure 1**.** The ceramic barrier wall isolating the two wells shall be recessed 510 μm below the top of the ceramic outer wall.

6.3.1.2 Electrical connections

The carrier shall provide isolated connections (4) to the individual diode cathodes and anodes in the form of brazed iron-nickel alloy (kovar) pins, 0.46 mm in diameter on 0.8 mm pad. The connections shall be oriented as indicated in Figure 1 with the two cathode connections adjacent to each other. The pins shall extend 9 mm from the back of the ceramic carrier. (See Figure 1.) A kapton cable shall be soldered to the kovar pins as indicated.

6.3.2 Substrate flow diagram and sample planning

6.3.3 Manufacturing Storing Instructions (MSI) Process and Material Specification

6.3.4 Qualification

6.3.5 Screening

6.3.6 Vendor Selection

6.3.7 Acceptance Criteria

6.4 Assembly of PhotoDiode

6.4.1 Requirements

6.4.2 Die Attach (Photo Diode)

6.4.3 Die Attach Controls

6.4.4 Wire/Ribbon Bond Controls

6.4.5 Manufacturing Standing Instructions Process and Material Specification

6.4.6 Qualification of Assembly and Testing

6.4.7 Epoxy Controls and Application Methods

6.4.8 Verification of all above controls

6.4.9 In Process and Final Inspections

7 QUALITY SYSTEM AUDITS AND CONTROLS

8 CONTROL OF PURCHASES

8.1 Manufacturing Controls

8.1.1 Drawings and Specifications

8.1.2 Production Process and Fabrication

8.1.3 In Process Inspection

8.1.4 Process Controls

8.1.5 Final Inspection and Configuration

8.1.6 Testing

8.1.7 Handling and Storage

8.1.8 Preservation, Marking, Labeling, Packaging and Packing

Finished assemblies shall be packed and shipped in protective electrostatic shielding containers.

9 END ITEM DATA PACKAGE

9.1 Customer Source Inspection

9.2 Nonconformance Control Board

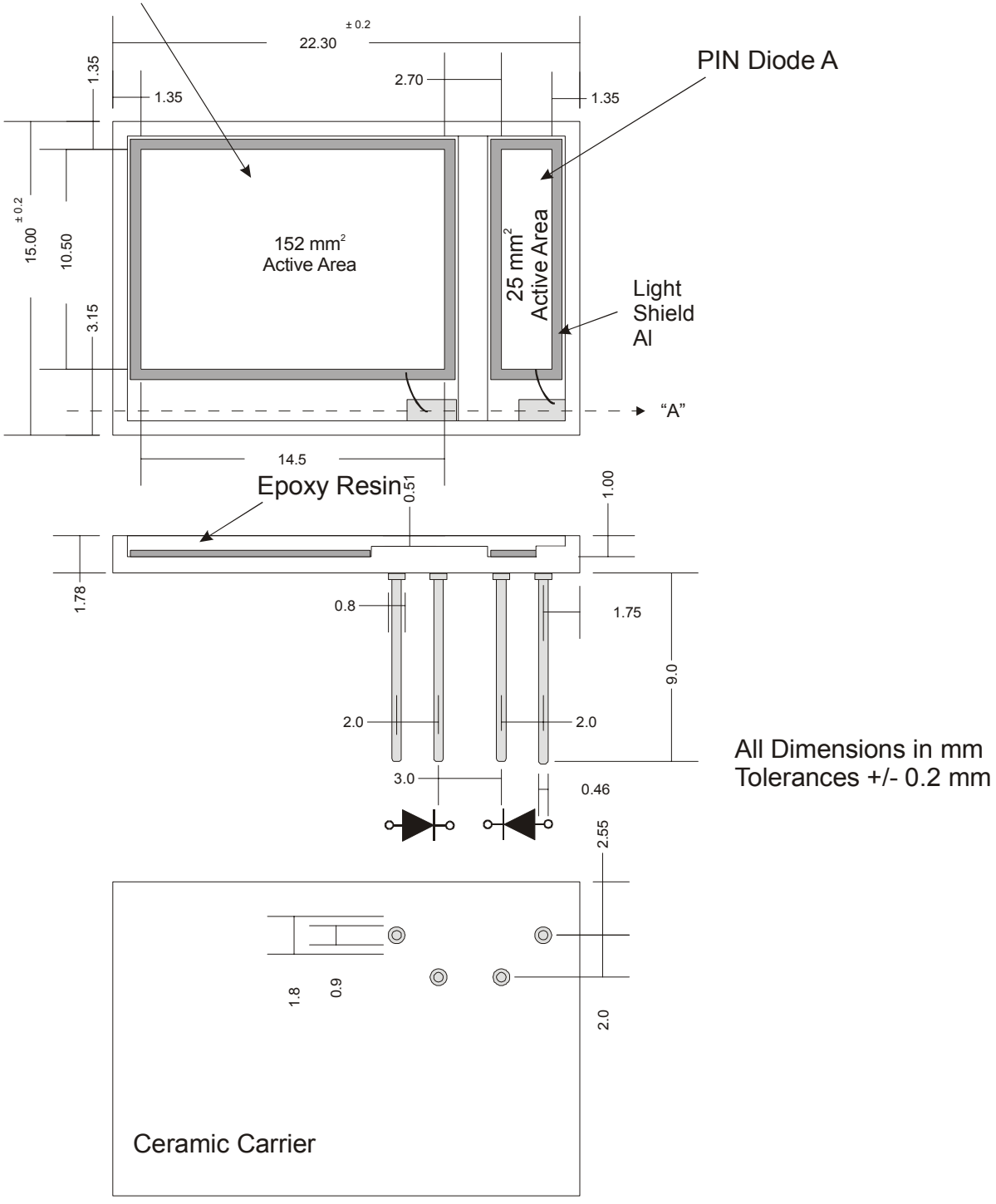

Figure 1. Mechanical Configuration of the GLAST CAL PIN Photodiode Assembly